Intelligent Logistics Management in Industry 4.0: An Application Based on an Automated Intelligent Vehicle

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Abstract

Companies that faces transport challenges and require logistics efficiency need to implement solutions based on automation, provided in Industry 4.0. Intelligent Logistics Management, satisfying the demanding requirements of the customer, using new technologies and advanced tools to control and to act along the supply chain are mandatory. To address this topic, this paper presents an application of an Automated Intelligent Vehicle.

Keywords

Intelligent Logistics; Industry 4.0; Automated Intelligent Vehicle; Application.

1. Introduction

Industry 4.0 is playing a central role in manufacturing and logistics is also stepping forward in order to gain properties and technologies, moving towards a logistics with Industry 4.0 support, namely, intelligent approach. Under this approach, this paper addresses intelligent logistics management, i.e., technology that manage and acts in a proactive way based on information that is collected, in this case, by an Automated Intelligent Vehicle (AIV).

To achieve the goal of this paper, the rest of this paper is organized as follow. Chapter 2 identifies the main contribution of the Intelligent Logistics Management in Industry 4.0. Chapter 3 presents the evolution of Automated Guided Vehicle (AGV) towards AIV. Chapter 4 presents the developed application based on an AIV focusing on Intelligent Logistics Management. To finalize, some conclusions are made in Chapter 5.

2. Intelligent Logistics Management in Industry 4.0

2.1. Industry 4.0

The concept of Industry 4.0 is requiring a special attention from all stakeholders (business, academia and society, in general). Mainly, due to the technological challenges that are presented and discussed driving to new applications and approaches. One of the many aspects of the influences that is discussed, is related to the decrease of the operational costs (Lee, et al., 2014; Schmidt, et al., 2015, Stock & Seliger, 2016), and logistics represents an important role in the subject.

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2.2. Intelligent Logistics

2.2.1. Logistics

Companies realize that distribution becomes, significantly, one of the costliest activities. Thus, there may be a need to treat all internal and external logistics as a priority area to promote efficiency and keep all costs under control. (Cooper, 1995)

One approach to decrease the operational costs of the distribution is to implement solutions based on automation, in order to gain efficiency, the same strategy has adopted by manufacturing. Therefore, to be efficient in logistics it is required an intelligent logistics management, satisfying the demanding requirements of the customer, using new technologies and advanced tools to control and to act along the supply chain.

2.2.2. Intelligent Logistic Management

The definition adopted by Logistics Council of Logistics Management (CLM) for logistic is "the process of planning, implementing, and controlling the efficient, effective flow and storage of goods, services, and related information from the point of origin to the point of consumption for the purpose of conforming to customer requirements". (Johnson & Donald Wood, 1999) So, based on this premise and by adopting and connecting to the new technologies and the more advanced tools, it is possible to move forward an intelligent logistics concept.

According to the Central European Institute of Technology (CEIT), the concept of intelligent logistics requires industries based on artificial intelligence. From application like SIRI to the autonomous vehicles, artificial intelligence is being developed very quickly, and for this reason several solutions in the area of logistics will be provided by this field. (Josef Harcko, 2016).

Currently, CEIT developed a framework based on 14 solutions, where all of them are interconnected and connected to the same online server, in order to address intelligent logistics. It is understood that not all solutions are integrated into the internal systems of companies, however, it is planned that it is the future that more options will be developed. The solutions presented by CEIT are (Josef Harcko, 2016):

- LINE SCHEDULING;
- RFID KANBAN;
- LOGIO CONTROL (LOGISTIC INBOUND AND OUTBOUND CONTROL SYSTEM);
- CO-WORKER PICKING SYSTEMS;
- LINE FEEDING SYSTEM;
- AGV MILK-RUN;
- RUNNER SYSTEM;
- AGV LINES;
- X-DOCK (cross-dock);
- EMERGENCY FEEDING;
- LOGISTICS ON WHEELS;
- QUALITY CONTROL WITH IMAGE PROCESSING;
- STANDARIZED WORK AND CONTINUOUS IMPROVEMENT;
- SUPPLY CHAIN MANAGEMENTE OPTIMISATION AND PLANNING.

It is perceived that within these 14 solutions there are some where the AGV (Automatic Guided Vehicle) is regularly used. Due to their flexibility, reduction of costs and times, these devices are increasingly used in the internal systems of the industries, whether in the production facilities, distribution centers and/or warehouses. AGV's limitation are mainly related to lack of autonomy, needing effort to be guided and monitored. The next generation of AGV's, based on the latest technology of the Industry 4.0, must have the ability to describe and understand the surroundings and to perform actions, i.e., an intelligent vehicle coined Automatic Intelligent Vehicle (AIV).

3. From Automated Guided Vehicle (AGV) towards Automated Intelligent Vehicle (AIV)

3.1 Industrial Automation

The industrial automation is a technique that can be used to reduce production costs and increase product quality. Processing computer systems such as robot manipulators, movables, conveyors, vision systems, programmable controllers and programmed by specific software, these automata can quickly respond to the various changes that can be required in the work field. Due to their flexibility, more industries are becoming automated, for example, many industries, such as automotive and automotive components, already have fully automated and robotized lines.

The integration of the automation elements that compose an industrial plant could be a challenge and their function as an all must be articulated. For example, communication between mobile robots and assuring that tasks of automatic transportation of products and parts performed by robots will maintain stock, such as raw materials or parts, in workshops must be guaranteed.

3.2 Automated Guided Vehicle (AGV)

Automated Guided Vehicle (AGV) is a battery-powered device that has the ability to navigate within an area completely automatically, and the navigation mode is performed by cables installed on the floor and the intervention area is covered by a radio-frequency signal. Through the antennas, AGV identify the different forms (as people and obstacles), follow the route and interacts with load transfer devices, if necessary (Shasha Wu, 2017).

Regarding safety issues, AGV's are prepared to circulate in open areas with human presence and are programmed in a way to avoid accidents, as mentioned and an example is present in Figure 1. These vehicles are composed with luminous and sonorous signals, and with magnetic technology. (Shasha Wu, 2017).

Figure 1. AGV systems pallet loading or unloading (Shasha Wu, 2017).

3.3 From Automated Guided Vehicles (AGV) to Automated Intelligent Vehicle (AIV)

Although AGV's ensure that many issues are solved in the logistic perspective due to their flexibility, corresponding to significant improvements in efficiency and safety, AGV's still have some limitations. The disappearance of the wires that are traversed by a radiofrequency signal and the pure automatic behavior, which follows an algorithm created, results with the new generation of AGV, the Automated Intelligent Vehicle (AIV).

AIV's are developed to solve all the challenges executed by AGV's, in a more effective way, responding to possible unforeseen events that may appear, in an autonomous way.

In Table 1, it is presented a resume with differences between AGV and AIV according to their characteristics and properties.

Table 1. AGV vs AIV.

	AGV	AIV
Path	Fixed to a certain pathway	Dynamic pathways
Reactive/Proactive	Reacts to obstacles	Learn from past experiences and proactively predicts new pathways
Recognition/Collaboration	Recognition of the surroundings	Share information, learning in the environment and interact with humans and things
Integration with the environment	Preprogrammed task oriented	Self-recognition, adaptive, active with other Things (RFID, …)
Learning process	Incremental	Complex based on an Artificial Intelligence approach

4. An Application based on an Automated Intelligent Vehicle

In order to present an example of Intelligent Logistics Management in Industry 4.0, an application based on an AIV was implemented in a shop floor of an electronic semiconductors manufacturing company. The AIV used is a MiR (Mobile Industrial Robots) Robot, model MiR100 (Mobile Industrial Robots S/A (2018)) (see Figure 2), and the mission assigned to this AIV is to transport materials between production lines and the central warehouse, using a customized shelf for this purpose.

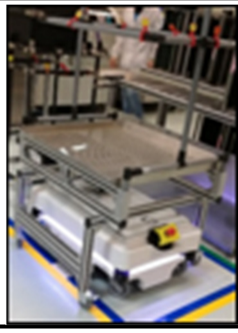
The main key features of the implemented AIV are:

- When loading a shelf, it can check if it is ready to be transported without order from the operator;
- Depending on the history of founded obstacles, AIV tracks routs tendency over the weekly days and defined a rout for each day;
- Identify the dimensions of the obstacles and activates a proper sound signal with a corresponding voice message;
- If for any reason the coupling is not properly locked to a certain shelf, it performs a new coupling;
- It moves safely and efficiently around people and obstacles;
- It is very flexible in the form of transport (bins, racks, lifts, conveyors or even a collaborative robot arm);
- It performs safe maneuvers;
- It maps working area in order to plan routes independently and effectively;
- Anytime that obstacles are presented in defined paths, AIV automatically drive around the obstacle and/or find an alternative route, within safe area;
- If the AIV does not find any alternative route, it sends an alert to the manager.

Figure 2. AIV performed, the model MiR100.

Founded on the key features and in order to create an Intelligent Logistics Management, the application based on an AIV was implemented and completed supported by 5 preparatory steps: 1. Mapping, 2. Edit Map, 3. Positions, 4. Mission, and 5. Rectify.
In Table 2 is presented the resume of the 5 steps, referring, for each step, a short description and a picture of implemented application.

Table 2. 5 preparatory steps of the implemented AIV.

Step	Name	Description	Picture
1	Mapping	To map the working area.	
2	Edit Map	After mapping the working area, the map is updated by identifying preferred routes and forbidden zones.	
3	Positions	After reaching the updated map, it is defined all the positions of places of materials loading and unloading, and place of charging.	
4	Mission	Missions are defined. The mission corresponds to the material transport between central warehouse and production lines, and corresponding rout. During the mission the AIV emits sound and luminous signals. It is programmed that if any problem emerges during a mission and the AIV does not solve it autonomously, the manager must be contacted by text message.	
5	Rectify	To adapt the mission according to problems that may arise, and update positions and map according to the changes performed.	

5. Conclusions

In this paper, it is stressed the importance of logistics and the role that technologies provided by Industry 4.0 could support the advances of logistics, namely, the Intelligent Logistics Management. The technology that is emphasized in conventional logistics is the Automated Guide Vehicle but to achieve forthcoming approaches, in accordance with Industry 4.0, an updated Automated Guide Vehicle is required, named Automated Intelligent Vehicle.

In order to present an application of Intelligent Logistics Management in Industry 4.0, it was implemented an Automated Intelligent Vehicle in a shop floor of an electronic semiconductors manufacturing company.

The implementation of this application was a successful kick-off project adopting Intelligent Logistics Management in the company. Further projects started to be considered after this application.

References

Cooper, J. (1995). *Logistics and Distribution Planning: Strategies for Management*. Kogan Page.

Johnson, J., & Donald Wood, P. R. (1999). *Contemporary Logistics, 7th edition*. Upper Saddle River: Prentice Hall.

Josef Harcko, M. B. (2016). *Intelligent Logistic Management*.

Lee, J.; Kao, H.A.; Yang, S. Service innovation and smart analytics for industry 4.0 and big data environment. Procedia CIRP 2014, 16, 3–8.

Mobile Industrial Robots S/A (2018). Retrieved 04 06, 2018, from MiR 100: http://www.mobile-industrial-robots.com/en/products/mir100/

Schmidt, R.; Möhring, M.; Härting, R.C.; Reichstein, C.; Neumaier, P.; Jozinovic, P. Industry 4.0-potentials for creating smart products: Empirical research results. In Proceedings of the International Conference on Business Information Systems, Poznan, Poland, 24–26 June 2015; pp. 16–27.

Shasha Wu, Y. W. (2017). Development and Application Analysis of AGVs in Modern Logistics. *Revista de la Facultad de Ingenharia U.C.V.*, 380-382.

Stock, T.; Seliger, G. Opportunities of sustainable manufacturing in industry 4.0. Procedia CIRP 2016, 40, 536–541.